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WHAT FUTURE FOR OUR ENTOMOLOGICAL HERITAGE?

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The themes of this address are to review some aspects of our current knowledge of invertebrate conservation, to consider the prospects for invertebrates and entomologists in Britain, and to examine how the activities of this Society and its members may contribute to the challenging task of handing down a rich and diverse fauna to future generations of entomologists.

This address is prepared from the viewpoint of one who enjoys recreational entomology as a spare time activity, but who is also privileged to be employed as an entomologist by the Nature Conservancy Council (NCC), having the responsibility for developing a national strategy for invertebrate conservation. Thus much of what is discussed here concerns what might broadly be termed 'conservation' issues, but I will attempt to lighten this rather serious-sounding topic by approaching the task from the perspective of someone who wishes to see entomological activities bring pleasure to entomologists, and indeed become more popular among naturalists in general. On the threshold of a new decade, and indeed approaching a new century and millenium, is an opportune time to consider what the future may hold in store for this Society, and for entomologists generally. The value of looking forward in this way lies in helping us to decide what we should do next to benefit our Society and the wildlife we study.

The current state of invertebrate conservation

Since Alan Stubbs spoke on 'Conservation and the future for the field entomologist' in his presidential address to this Society for 1982, invertebrate conservation has continued to develop in Britain. News of some NCC projects has been summarized in exhibits displayed at the Annual Exhibition of the Society in recent years. Many significant sites for invertebrates have been identified through the valued contributions of entomologists to the Invertebrate Site Register, and the location of many threatened species is now better known. Good progress has been made in identifying some basic principles for tackling invertebrate conservation. The wider dissemination of these principles through workshops and seminars for conservationists in the NCC, in the county trusts and in other conservation organizations has been a central activity for my colleagues and me. the more people who understand how to tackle invertebrate conservation at a basic level — even if they do not study the animals themselves — the greater the probability that the needs of invertebrates will be more widely incorporated in conservation plans and tasks. This will improve the prospects for many important invertebrate sites, including sites of special scientific interest (SSSIs), national nature reserves and county trust reserves. There are new opportunities arising outside conservation sites as well, for example, through changes in agricultural policies. However, if land taken out of agricultural production is to benefit more than common and widespread invertebrates, the habitat needs of the more demanding species must be sustained.

At present, the rate of loss of semi-natural habitat due to agricultural activities has probably eased slightly, particularly in southern England. In many cases this is because there is relatively little land left where agricultural improvement is economically viable under the present system of agricultural grants. However, personal observations in northern and western Britain indicate significant changes in agricultural land use are still underway in these areas. In contrast, within south-east

England increased economic activity is resulting in many development proposals being put forward which will affect areas of high wildlife value, including SSSIs. Similar developments are increasing in other regions.

Following the start of Channel tunnel construction there is now a tremendous impetus for developing transport links, housing and industry within Kent. This is resulting in considerable pressure to develop many important sites for insects and other invertebrates in a part of Britain which has a rich fauna, including many rare and threatened species. These problems will remain as long as intensive economic development is concentrated within this relatively small area. Even Dungeness, an internationally important site, is under threat from a variety of proposals, including the demand to extract more shingle to supply aggregate for the construction industry. As an example of the work this creates for the regional staff of NCC, in Kent during 1988 there were 383 formal consultations over proposals affecting SSSIs and 190 affecting the wider countryside. For the south-east region as a whole there were 1221 SSSI and 467 wider countryside consultations, the workload for Surrey and Sussex being similar to Kent. The figures for south and south-west England regions are almost as high.

It is interesting that the numbers of naturalists who are members of societies for those studying insects, plants and birds are roughly inversely proportional to the numbers of species in these groups (Fig. 1). Despite this imbalance, the conservation needs of insects and other invertebrates are becoming better known. This is a time of great activity in invertebrate conservation, and there are many opportunities to achieve more, as well as obstacles to overcome.

Fig. 1. The number of Britain's resident insects, higher plants and breeding birds, and the membership of the Royal Society for the Protection of Birds, the Botanical Society of the British Isles, and the British Entomological and Natural History Society.

Legislation and collecting

I will not review this topic in depth, but instead briefly state my personal opinions on this contentious subject. I share the views of the majority of entomologists that habitat protection and management is the area where legislation has the most to offer invertebrate conservation. This is in contrast to the situation for many vertebrates, where species protection is important for preventing damaging persecution by man. In my view species protection legislation (as applied to those species listed on Schedule 5 of the Wildlife and Countryside Act, 1981) should be confined to the small number of species where collection of even a few individuals could adversely affect the remaining populations. For these cases legal protection is entirely appropriate and necessary. In practice that is now the position in Britain, though there will always be disagreements about the wisdom of scheduling particular threatened species. Rather than dwell on the details here, it seems more profitable to look at what is happening elsewhere, and to try to anticipate what may happen in Britain over the next few years.

European legislation has been reviewed in detail by Collins (1987). In many other

European countries, species protection legislation has been seen as the primary legislative tool for developing insect conservation. However, without effective action on the ground, by themselves such measures have negligible positive effect. Indeed, species protection legislation which does not safeguard the critical habitat of threatened invertebrates, or develop action plans for their conservation, can be counter-productive. The harm arising from lengthy protective lists lies, firstly, in the bureaucracy necessary to administer them, which takes resources away from more productive conservation tasks. Secondly, if licences are required for the studies necessary to gain understanding of how to conserve these animals, then some entomologists will be deterred from involvement with conservation initiatives. Thirdly, such legislation can give the false impression that the field entomologist is not to be trusted, and that his activities are mainly responsible for causing declines of invertebrate populations. What follows from this is an alienation of the entomological community from those working in conservation. This is at a time when greater co-operation is needed between entomologists and conservationists if rare and threatened European invertebrates are to be saved from further declines and extinctions.

Naturally, it is incumbent upon entomologists to behave responsibly when collecting or studying threatened species. The activities of some commercial collectors, and a minority seeking to finance their entomological excursions through the sale of 'surplus' material, have catalysed the growth of inappropriate species protection legislation in parts of Europe. Looking forward on this issue in Britain, it is my aim to pursue a strategy of retaining a small list of invertebrates given full protection under Schedule 5, and to oppose the wider listings urged by some conservationists. At the same time it is essential to develop here further special measures to conserve threatened species, both those on Schedule 5 and others given Red Data Book status. In future, conservation bodies need to devote more effort and resources to research on habitat needs, to site protection and management. Also, greater consistency is required in the monitoring of threatened species populations, to assess the success of action taken.

The role of responsible collecting in enabling entomological studies to progress needs to be stated clearly, and I would like to take this opportunity to say that from inside NCC I will continue to support the case for sensible entomological collecting within the framework of the JCCBI 'A code for insect collecting' (1972). Taking specimens is necessary to further advance our understanding of the taxonomy, status and distribution of the many small and sometimes enigmatic species which cannot be reliably identified in the field. There are many undescribed species still awaiting discovery in Britain — a rich field for the inquisitive naturalist. Even where currently we believe we can identify to species level in the field, a new and closer look (with more detailed examination of structural features, or using techniques such as enzyme of chromosome analysis) frequently reveals additional cryptic taxa which have their own distinctive ecological and behavioural properties. In future the need for entomological studies, with the integral role played by field sampling and collecting, must be more widely promulgated among conservationists and the general public, otherwise the growth of protectionist attitudes will threaten the continued existence of field entomology as we know it today. At a time when collecting many other types of wildlife is widely regarded as unacceptable, the rational case for responsible collection of invertebrates must be argued. After all, if important wildlife sites are to be better documented and understood, then the recording and monitoring of invertebrates must be encouraged rather than hindered.

For the butterflies and dragonflies, most recording for studies of status and distribution does not depend upon the retention of voucher specimens. However, even for these groups it may sometimes be necessary to keep an individual which defies immediate recognition. Also, many youngsters begin an interest in entomology by collecting a few common species in such groups, and by keeping adults or rearing through from the early stages. Such interest deserves encouragement and development towards a deeper involvement in entomology. The future of this Society, and of the subject in general, depends upon recruiting and holding the attention of enthusiastic youngsters. Therefore, I am in favour of tolerance towards some collecting of these groups rather than total prohibition as has happened in some other European countries.

Establishments, introductions and related issues

These are controversial subjects, and again the JCCBI has produced sensible guidelines in 'Insect re-establishment — a code of conservation practice' (1986). I believe that when properly carried out, these activities have a positive role to play in the conservation of some threatened species, at present mainly among the Lepidoptera. In future there will be opportunities to extend the use of re-establishments to other invertebrate groups. However, I would like to sound a note of caution here, because some recent enthusiasm for insect re-establishments as a conservation tool has not, in my view, been tempered with sufficient realism.

Re-establishments should be used to try to reverse the declines which have taken place in groups such as Lepidoptera where there is enough knowledge of captive rearing and habitat requirements. However, the lack of this knowledge for most invertebrates creates practical limitations in the value of this approach. For example, when a relatively conspicuous butterfly disappears, because a site is no longer suitable, many other insects which share a need for similar habitat conditions may also disappear. However, if appropriate habitat conditions are restored, it may be possible to re-establish the lost butterfly — a perfectly valid conservation activity — but it will not be possible to bring back the numerous unseen beetles, bugs, flies and the myriad other invertebrates which comprise the great majority of the fauna. The site with the re-established butterfly will remain impoverished for much of its invertebrate fauna, though a superficial inspection might suggest it has been completely restored to its former state. Therefore, those sites which retain continuity of conditions, and their associated scarce butterflies and other invertebrates, are extremely precious because they cannot be recreated. They demand our best efforts to maintain their richness and variety intact, hence preventing site extinctions in the first place is preferable to regarding loss of invertebrates as being generally reversible.

In my view the value of introductions, habitat translocations and habitat creation for invertebrate conservation is rather different and more limited than that of re-establishments. Habitat translocations are now promoted, by those wishing to develop important conservation sites, as viable alternatives to *in situ* conservation. While it may be possible to succeed in giving an illusion of success through what are often cosmetic publicity exercises, severing assemblages of plants and animals from the location where they have developed over long periods of time is not a rational alternative to the proper protection of SSSIs and other significant sites. However, if the impression is given that, for instance, a handful of attractive and conspicuous insects constitute an acceptable invertebrate assemblage, rather than part of that fauna which should be present alongside many other less observable species, then the perceived value of *in situ* conservation stands to be undermined. At a time when high cost and high profit development is growing in Britain, such erosion of the conservation case could be most damaging. Introductions, and habitat creation have a central part to play in urban conservation, and the restoration of areas denuded of wildlife interest through industrial developments or intensive agriculture. However, they are not alternatives to conserving ancient, semi-natural habitats.

The need for a better understanding of invertebrate conservation

It is paradoxical that those life history features, physiological characteristics, and specialized adaptations, which have made invertebrates so successful in terms of their diversity and abundance, also render them vulnerable to environmental changes caused by man. It is perhaps the general success of invertebrates, coupled with their small size and often retiring habits, which hinders perception of the fragile status of many species. Excepting butterflies, there is little general appreciation by naturalists, or the general public, of the scale of invertebrate declines in recent decades. Losses of higher plants or birds are more readily recorded, receive much greater attention, and are generally viewed with more concern than the disappearance of invertebrates. Also, because some invertebrates are notorious as crop pests or disease vectors, many people do not recognize the need for invertebrate conservation. We have much to do through education to demonstrate that most invertebrates are beneficial to man, or economically neutral, and that the activities of many species are essential to the proper functioning of healthy ecosystems.

The scale of the problem of declines in invertebrate species has been well summarized elsewhere. Suffice it to say that 1786 taxa were included in the Red Data Book for British insects (Shirt, 1987) as being currently under some degree of threat. This represents 14.5% of the species in the insect groups reviewed. It is noteworthy that almost all the data on the status and the degree of threat to these species originated from studies carried out by amateur entomologists. If we accept that many species are vulnerable to further declines, and even extinction in Britain, then what action can we take? The following sections attempt to review briefly some basic principles for conserving invertebrates, and to put into words intuitive concepts familiar to many field entomologists. Although it is necessary to have a detailed understanding of the needs of individual species to conserve them successfully, a grasp of the basic principles is what we must communicate first to those working in conservation.

The influence of weather and geographical factors

There are large scale effects of Britain's climate, and also of variations in weather from year to year, which influence the distribution and abundance of invertebrates. It is well known that for most groups there is a decline in the number of species from south to north, which has been linked to the higher average temperatures and sunshine hours required by many southern elements in our fauna. However, there are considerable differences between groups in this species richness gradient. The butterflies (Fig. 2) show a marked decline from south to north. The data for post 1970 resident species has been abstracted from Heath, Pollard & Thomas (1984) here excludes the large copper, large tortoiseshell, the clouded yellows, red admiral, painted lady, and species which became extinct before 1970. This pattern might be expected for insects which are typically sun-loving, and whose larvae exploit hostplants growing in hot microclimates. Such conditions enable them to complete their life cycles within the short growing season in our generally cool and cloudy climate.

For another group of insects, the snail-killing flies or Sciomyzidae, the decline in species richness from south to north is much less pronounced. The data for Fig. 2 has

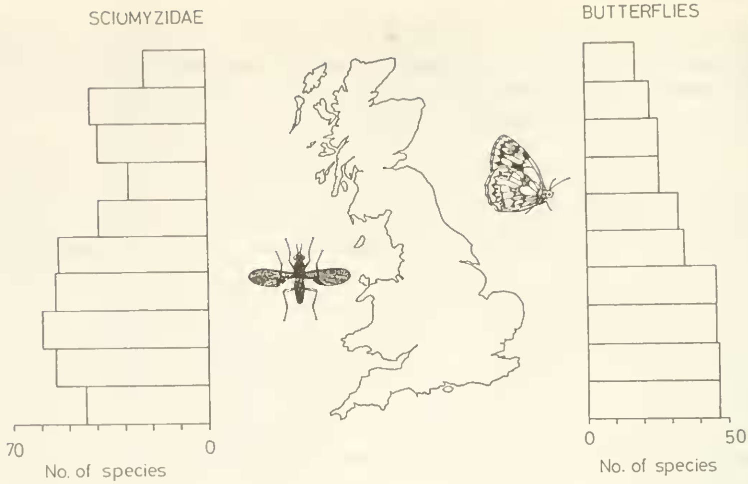

Fig. 2. The changes in species richness with latitude in Britain for butterflies and snail-killing flies.

been abstracted from Ball & McLean (1986). These flies have larvae which are predators or parasitoids of terrestrial and aquatic molluscs. Although some Sciomyzidae are adapted to attacking terrestrial molluscs in 'hot' calcareous grasslands or dunes, in common with their prey the majority of these flies live in wetlands and woodlands. These cool, humid situations are present throughout Britain, and if the recording coverage were as good as for the butterflies, it is likely that there would be even less of a fall off in species numbers than is shown here.

Some recent evidence that butterfly populations are more variable in abundance in northern Britain than in the south has been published by Pollard, Hall & Bibby (1986). They found greater fluctuations in the index values for the meadow brown at five sites in Scotland compared with five sites in southern England (their figure 9 on page 27). This is but one aspect of the findings from the national Butterfly Monitoring Scheme, which has convincingly shown the effects of weather factors in causing widespread fluctuations in butterfly numbers from year to year. It is likely that many other invertebrates will also be affected by weather in similar ways. What are the implications of this for conservation? Considering the higher rates of habitat loss and change in the south, coupled with observed trends in species richness, suggests that more invertebrates are at risk from habitat loss and change in the south. However, invertebrate populations which fluctuate more in the north may be more vulnerable to local chance extinctions in the long term. Also, recolonization may be slower here, because the average weather conditions are cooler and cloudier, and this may restrict dispersal and colonization.

If a general change in our climate takes place in response to global warming, invertebrates are likely to respond more rapidly than most other wildlife. At present it is unclear how our weather patterns might change, but if invertebrate species are to respond successfully by changing their distribution and range, there must be the opportunity for them to move to suitable habitat within the distance they can disperse and colonize. Because remaining examples of good quality habitat are generally isolated from each other, the balance of probability is that many of the scarcer, threatened invertebrates are not sufficiently mobile to move on to new sites.

Unless there is the chance to promote their dispersal along suitable 'corridors' (which is difficult to envisage because of the specialized needs of most species), then climate change coupled with the limited areas of semi-natural habitat remaining, may cause substantial losses for our invertebrate fauna in future.

Characteristics of invertebrates

Most invertebrates share some fundamental characteristics which are familiar and obvious to entomologists, though they are less well appreciated by many conservationists. These characteristics have major implications for the practical conservation of invertebrates, which presents a distinctive challenge perhaps greater than that set by most plants or vertebrates.

Annual life cycles. The great majority of insects and other invertebrates have annual life cycles, though a few species have more than one generation each year, and some others may spend one or more years in their early stages of development. *Implications*: appropriate conditions must be present for the growth, development and reproduction of most invertebrates every year. Even a break in continuity of a single year in the availability of a vital habitat resource, is likely to result in extinction of associated invertebrate populations. This is in contrast to many plants, which may persist through unfavourable conditions in a vegetative, non-reproductive condition, or can utilize dormant seeds or rootstocks to survive. Additionally, many vertebrates, though by no means all, have longer generation times, with more than one year spent in an adult, potentially reproductive condition. This provides a possible mechanism for overcoming unfavourable conditions.

Life stages have different needs. The complex life cycles of insects and many other invertebrates are well known to entomologists and other naturalists. For many species the different life stages have contrasting ecological requirements, which must be present every year within the areas they inhabit. *Implications*: habitat needs of invertebrates are usually more diverse than those for higher plants, or many vertebrates , and generally must occur in close juxtaposition because many invertebrates have limited mobility (see below).

Specialization. Invertebrates have evolved to exploit an immense range of niches, many of which are very narrow and specialized. This is one reason why many invertebrate species can co-exist in terrestrial habitats; they have partitioned the available resources very finely. Because of their small size they can exploit tiny 'packets' of food resources, which would be too small for most vertebrates to utilize. For example, flying insects can remove minute amounts of nectar from each flower they visit in order to fuel their activity. Additionally, different species show individual preferences for the flowers in bloom at any one time, and indeed some adult solitary bees will forage at only one flower species for pollen and nectar. *Implications*: a wide range of potential niches must be consistently sustained in any habitat, if the full characteristic invertebrate fauna is to persist and thrive.

Restricted mobility. Although some invertebrates have good powers of dispersal, for example, adult *Aeshna* dragonflies or certain butterflies such as the vanessids, many are relatively immobile. This might be expected for invertebrates such as molluscs, which are not noted for their speed over the ground, but it is becoming apparent that many insects capable of flight have behaviour patterns which confine most individuals to relatively small areas. This has been elegantly demonstrated for the silver-studded blue (Ravenscroft, 1986) and the heath fritillary (Warren, 1987*b*). *Implications*: the varied ecological needs of each invertebrate species must be consistently sustained within their dispersal range. For species exploiting ephemeral habitat conditions or resources, a fugitive lifestyle leads to frequent colonization followed by local extinction. When habitats become fragmented, or the required conditions are not created through management or disturbance, then more general declines are likely to set in. Even if the required conditions are subsequently re-established, they will not be exploited if they are beyond the dispersal range of the species concerned.

Microclimate needs. Invertebrates are small, and largely regulate their body temperature through behavioural mechanisms. In our variable temperate climate, weather conditions are frequently a decisive factor limiting invertebrate activities. There can be conflict between the need to bask in the sun to raise body temperature and hence increase the level of activity, and the need to avoid water loss which is higher in sunny and windy conditions. Also, different invertebrates are adapted to exploiting particular microclimate conditions, and even within small areas of the same site, there will be considerable variation in the nature of the fauna resulting from such factors as the levels of sun or shade, exposure to wind, and degree of humidity. *Implications*: the physical structure of a habitat is a crucial factor in determining the potential range of microclimate conditions which can be exploited by invertebrates. This physical structure is modified by human influence through management, such as the level of grazing on grasslands and heathlands, or the pattern of felling or coppicing within woodlands. Invertebrates typically respond to microclimate changes more rapidly and sensitively than higher plants or vertebrates.

Some habitat features required by invertebrates

The characteristics of invertebrates discussed above result in some habitat features being of vital importance for the survival of many species. Although these features will be familiar to entomologists as good spots to search, their significance is often overlooked by other naturalists because plants and vertebrates are not so dependent on these situations. However, a wider recognition of their importance in future could lead to more effective conservation of their associated invertebrate assemblages.

Bare ground. On a variety of substrates bare ground offers a hotter microclimate than vegetated ground, and also clear hunting terrain for many predatory invertebrates. Some species bask to raise body temperature, others exploit oviposition sites on bare ground. Whether on damp peat, dry sand, or on other soils, bare ground is a vital feature in many terrestrial and water edge habitats. The distinctive invertebrate fauna dependant on bare ground includes many species which will disappear once the surface becomes vegetated; these include ground nesting bees and wasps, ground and rove beetles, butterflies, bugs, robber and bee flies. All too often bare ground is viewed by botanists and other naturalists as being ground deficient in vegetation cover as a consequence of mismanagement, and active steps are taken to promote plant growth and succession. Firm, bare sand on coastal dunes, along heathland paths and tracks, south-facing sand cliffs in old sand pits and on steep exposures elsewhere, all have their own associated fossorial aculeates. River shingle (Fig. 3), and silt or mud beside rivers and ponds are home to many beetles, bugs and flies. There are many other examples which could be given, suffice it to say that bare ground is an important habitat feature which has its place wherever the activities of man or grazing animals can sustain it. *Implications*: bare ground must be continually created and re-established in terrestrial habitats if the associated invertebrates are to survive. The extent of bare ground should be measured routinely as part of nature reserve monitoring, and increased levels of appropriate management should be applied when the area of bare ground decines.

Vegetation structure. Many insects are associated with host plants growing in a narrow range of ecological conditions, often in association with plants of a particular

Fig. 3. The River Spey at Aviemore. River shingle supports a specialized invertebrate fauna, including a high proportion of species not found in other habitats. However, wildlife interest for plants or vertebrates is low, and it is only recently that the invertebrate conservation interest has been more widely appreciated.

stature and 'apparency'. Good examples are known for butterflies, for instance, those associated with chalk grassland have distinctive turf height preferences (Butterflies Under Threat Team, 1986). *Implications*: levels of grazing in grasslands, heathlands and coastal habitats, and patterns of clearance in woodlands, are examples of management regimes whose intensity determines the nature of the associated invertebrate fauna. The decline of many chalk grassland butterflies following myxomatosis in Britain, has been convincingly shown to be the consequence of the growth of taller vegetation (Thomas, 1983*b*; Thomas *et al.*, 1986). Even though the correct larval foodplants can still be present, they are essentially unavailable because they are too cool and shaded within a longer sward. The monitoring and retention of suitable vegetation structures is a key point for future successful invertebrate conservation in Britain.

Shade. Many insects require hot, sunny conditions for their development and activity, notably butterflies (Thomas, 1986). Others prefer cool, shaded areas to avoid desiccation. The shade lovers include many flies, molluscs, spiders, beetles, isopods and myriapods. They comprise much of the fauna associated with dead wood, leaf litter and other decaying vegetation, some water margin species, and those found in tussocks. *Implications*: the abandonment of coppicing and general neglect of ride management in many deciduous woods, means that shaded conditions are more widespread now than in the recent historical past. This has resulted in the decline of many woodland butterflies such as the heath fritillary (Warren, 1987*c*). However, there is a need for shade in old forests which have rich dead wood faunas, and along some sections of rivers. Here unnecessary felling or other disturbance to these areas should be avoided.

Aspect. South-facing slopes warm up faster, and reach higher temperatures near to ground level, than slopes with other aspects. North-facing slopes are coldest, while areas which are predominantly east– or west-facing are warmer at the beginning and end of the day respectively. Shelter from prevailing winds can also result in glades in woodland or scrub, or south-facing hollows in open habitats, achieving a locally hot and favourable microclimate for promoting invertebrate activity. *Implications*: when planning site management, it is necessary to recognize the effects of aspect on the composition of the invertebrate fauna. Species requiring warm conditions, especially near the northern limit of their range, will favour slopes with a more southerly aspect, while those living in cool, shady and moist situations will generally prefer slopes with a northerly aspect. However, the distribution of individual species can change from year to year according to weather factors and patterns of management.

Water levels. It is axiomatic that wetland habitats should have water tables near the ground surface. However, in many parts of Britain land drainage and water abstraction make this increasingly difficult to achieve for the site manager. If wetland sites dry out, shrubs and trees will become established on previously open habitat, and the margins of open water will change, with shallow water areas drying out seasonally or permanently. Although the successional encroachment by carr can be resisted by some form of rotational clearance, possibly combined with grazing, the drier ground surface will become unsuitable for many soil-dwelling species. The water margin invertebrate fauna (which is estimated to comprise in excess of a thousand species in Britain) is dependant upon distinctive hydrological regimes in different habitats. Lowered water levels will result in the loss of characteristic water margin invertebrates in wetland habitats, for example, from the edges of ditches in grazing levels marshes. Also, the freshwater fauna will suffer when smaller water volumes in pools, ponds and ditches lead to increased nutrient concentrations leading to growth of algae, loss of macrophytes, and depletion of available oxygen. *Implications*: achieving hydrological control for wetlands is the first consideration when planning the conservation of their invertebrates. This can be a high, relatively stable water level for many peatlands, whereas grazing levels marshes and other mineral marshes may have naturally lower water levels through the summer and autumn. Flood plain wetlands may have more erratic water levels, which can fluctuate greatly over just a few days. However, over-deepened river channels created to improve land drainage have led to a more general drying out of old water meadows and other riverside areas. Breckland meres and pingo hollows have naturally fluctuating water levels, but the increased rate of water abstraction, much of it for agricultural irrigation, threatens more lengthy desiccation of these pools through a permanent lowering of the water table. Temporary pools support invertebrates not found in other water bodies, for example, the fairy shrimp *Chirocephalus*. An understanding of the past as well as the present hydrology is vital for the successful conservation of wetland invertebrates.

Accumulations of dead material. Many invertebrates feed on dead organic materials, breaking these down and enabling nutrients to be re-cycled. They often act in co-operation with fungi, typically invertebrates undertaking physical break-down, and fungi biochemical degradation. Examples of substrates exploited include dead wood, leaf litter, carrion and dung. Of these the first supports the greatest number of invertebrates of conservation concern (see Speight, 1989) with many species having declined as a consequence of the long history of intensive forest exploitation by man in Britain and western Europe. Only a handful of sites remain with a good representation of what are now termed saproxylic (from the Greek rotten-wood) invertebrates. Concern for this fauna has resulted in a recommenda-tion from the Council of Europe Committee of Ministers to governments of member

Fig. 4. Mark Ash in the New Forest. Ancient oak and beech trees in the New Forest support many threatened invertebrates associated with such features as decaying timber, rot holes, sap runs and fungi.

states (1988) urging action to conserve these threatened invertebrates. *Implications*: dead wood and other natural accumulations of organic material should be recognized as significant features for invertebrates on conservation sites and elsewhere. On sites known to have exceptional assemblages of threatened invertebrates associated with dead wood (such as Windsor Forest and the New Forest, see Figure 4), future management must seek to retain the maximum number of ancient trees and leave in place standing and fallen dead wood.

Management principles

Consideration of the characteristics of invertebrates, together with the habitat features they require, demonstrates that continuity in the availability of resources, and hence consistency of approach on management issues are vital. The general principles discussed here are only the first stage in planning conservation management for a site. For example, the integration of detailed prescriptions for individual threatened species is a further step which is highly desirable whenever possible. With the high rates of loss of semi-natural habitats in recent years, many conservationists have quite naturally concentrated on site protection. This has led to a relative neglect of sound, consistent management, which has probably been more damaging to invertebrates than to other wildlife. Short-lived early successional stages, which are essential for many invertebrates, have been particularly disadvantaged through interruption of the regular intensive management input required.

Keep traditional regimes. Many habitats in Britain have been intensively managed by man for centuries. Familiar examples include woodland coppicing, long-established patterns of grazing of heathlands and grasslands, and hand clearance of ditches on grazing marshes. These have all resulted in the development of distinctive assemblages of invertebrates adapted to exploiting the conditions created. The abandonment of these practices has led to the decline and disappearance of many of the scarcer, specialized invertebrates most closely tied in to features created by annual, intensive management. *Implications*: whenever assessing the type of conservation management for an area which has received consistent treatment in the past, the safest option to consider first is to stay as close as possible to established practice. This usually applies even when the management appears to be damaging, for example, regular burning or over-grazing of early successional stage habitats. Initially, such areas can look aesthetically more attractive when released from intensive management, but this is misleading because their invertebrate fauna, and eventually the flora and other wildlife will change fundamentally.

Retain mosaics. Almost instinctively, many entomologists home in on places where there is varied vegetation structure, for instance, grassland with a combination of tussocks and short turf with some bare ground, or the salty pools and flowery expanses of the upper reaches of saltmarsh. This is because experience has shown that such spots are good for finding many species. In the first example cited, man influences the structure by regulating the intensity and duration of grazing, while in the second example given, natural processes sustain the mosaic. The different needs of immature compared with adult insects, or of adult insects when foraging for food in contrast their requirements for ovipositing, can be catered for by the close juxtaposition of short and tall vegetation. At a larger scale, the occurrence of different habitats in combination is essential for some invertebrates, for example, those living in shaded woodland as larvae, but feeding at sunlit flowers as adults. *Implications*: a change in the nature or intensity of management can result in the loss of mosaic structure, with a consequent reduction in invertebrate interest. An awareness of the value of mosaics at different scales is needed if nature reserves and other areas are to remain at their best for invertebrates.

Use of rotational management. Many habitats have features which are best sustained by some form of rotational management. Examples include woodland rides and coppice panels, ditches on grazing marshes and *Phragmites* or *Cladium* fens. In each case there are invertebrates which depend upon this repeated imposition of cutting or clearance to regenerate early successional stages. *Implications*: there is a contrast in approach between these forms of rotational management which are best undertaken on a constant time cycle, and those which require some temporal flexibility. In general, ride management, coppicing, pollarding, fen cutting, cutting or burning of heathlands, and grazing of grasslands are best carried out on a reasonably constant cycle. However, ditch clearance, scrub control and cutting vegetation beside water bodies, can be undertaken more irregularly, with the operation carried out when the degree of regrowth has reached the desired successional or structural stage. In either case a good maxim is 'little and often', with some management activity each year on a systematic basis, rather than occasional intense activity with an absence of early successional stage conditions in those years when no management takes place.

Diversity can be dangerous! Digging new ponds, or planting trees in open grassland or heathland, are examples of measures designed to increase habitat diversity, sometimes with the intention of benefiting invertebrates. *Implications*: there can be problems maintaining the original wildlife interest of sites subjected to poorly conceived diversification. For instance, the increased evaporation from a new pond can lower the water table in the vicinity, thereby damaging adjacent wetland communities. Planting trees can promote undesirable scrub establishment or shading of open ground species. Within ancient semi-natural habitats proposals to increase diversity should be examined very critically. Conserving sites for their primary interest, rather than creating diversity for its own sake, should be the aim.

Conservation steps

A rational sequence of steps can be identified to tackle conservation issues effectively. All too often conservation activities are carried out with great enthusiasm but without a systematic approach to solving problems. Adoption of a check list of steps to tackle site and species conservation should help us to achieve better results in future.

Identification: species and sites. Concentrating efforts on threatened species declining and in danger of extinction, and on sites with exceptional assemblages of such species, are but two examples of the need to identify conservation targets accurately. Assessment of the degree of threat to individual species always involves a considerable degree of subjectivity, even when ranking and scoring systems are adopted (as in the British plant Red Data Book, Perring and Farrell 1983). Much has been written on site assessment for invertebrates (see references in Luff, 1987; Eyre *et al.*, 1986). Ideally, gathering data in a systematic way, which allows a classification to be created which groups sites with a similar fauna together, should precede assessment procedures. This should be coupled with the need to ensure good representation of the strongest populations of rare and threatened species and the richest known assemblages. Because of the lack of systematically collected invertebrate data for most habitats in Britain, this latter representational approach currently offers the best practical solution to identifying significant invertebrate sites.

Understanding: biology and ecology. To prepare conservation plans for threatened species or management plans for sites, requires an understanding of the life history requirements for the species and knowledge of the responses of communities and populations to alternative management regimes. Butterfly ecologists such as Jeremy Thomas and Martin Warren have developed an approach for threatened butterflies which is an excellent model for adoption and adaptation when investigating other groups. There is so much still to learn about invertebrates in these contexts, and there is tremendous scope for members of this Society to contribute original findings. Although Britain has the most intensively studied invertebrate fauna in the world, many species have undescribed early stages and unknown habitat needs, and the distribution and status of species outside the 'popular' groups is frequently unclear.

Implementation: safeguard. When the data has been gathered and the plans made, the next stage is implementing the correct course of action on the ground. Site safeguard depends on the availability of suitable legislation, resources for conservation and political support.

Implementation: management. Ensuring consistent application of appropriate management is the next step, and this is often vulnerable to human factors. Conservation officers and reserve wardens change regularly, and they naturally differ in their interests and approach to nature conservation. It is the role of reserve management plans to set clear long-term goals and to encourage consistent standards of implementation. There is great potential for entomologists to be more involved in reserve management to ensure that what is done is compatible with the needs of invertebrates.

Monitoring: feedback to implementation. Because invertebrate populations respond rapidly to environmental changes, they have great potential as indicators of habitat health and conditions. The Butterfly Monitoring Scheme is the only national invertebrate monitoring project linked directly to the needs of site conservation.

Ideally, additional invertebrate groups, with habitat needs different to those of butterflies, should be monitored consistently on nature reserves and other sites. Due to lack of resources and knowledge this is unlikely to come about in the near future. However, it is possible to envisage that consistent monitoring of habitat features, of value to invertebrates, could be incorporated within the monitoring of SSSIs, county trust reserves and other significant sites. Some suggestions of how this might be done are listed in Table 1. Detailed monitoring of invertebrates which respond rapidly to changing environmental conditions is preferable because it gives direct information about their abundance. However, this is time-consuming and difficult compared with the cruder measures outlined here. In the short term it is more practical to envisage a wider adoption of habitat feature monitoring, which should serve to raise awareness of what invertebrates require, and will detect gradual habitat changes taking place over long periods. Fixed point photography is a rapid, cheap and effective technique in many habitats.

Table 1. Some techniques for monitoring habitat features of value to invertebrates (references give information on methods).

Bare ground	Use target notes on site maps Measure percentage cover using quadrats
Water levels	Use dip wells (Rowell, 1988)
Ride structure	Measure ride width and tree height
Ride shading	Hemispherical photography (Warren, 1985)
Vegetation height (grassland etc)	Use hardboard disc (Butterflies Under Threat Team, 1986)
Fixed point photography	Use to assess vegetation structure and composition (Smith *et al.*, 1985)
Aerial photography	Use to assess large scale vegetation features (Howard, 1970; Paine, 1981)
Numbers of flowers for key plants	Count standard length sections in transects along woodland rides, count numbers in quadrats, or estimate flower numbers using DAFOR* scale.

Communication. For those working on conservation, access to up-to-date information about all aspects of invertebrates is nearly impossible because the published literature is scattered in so many books and papers. Even when the data have been obtained, which would enable a site or species to be conserved successfully, ensuring it reaches those who make conservation decisions is difficult to achieve. It has been a central aim of the NCC's Invertebrate Site Register to communicate relevant information on invertebrates to those working at a practical level in conservation. The national species reviews currently in preparation will collate what is already known about scarcer species, and draw attention to gaps in knowledge.

Long-term goals and perspectives. One of the major challenges facing conservationists is setting positive long-term goals and objectives. Much of the process of site defence is viewed by our opponents as essentially negative. This is because of our need to object to proposals which are perceived as economically positive, in that they do such things as create employment, or raise productivity or income, from areas of land. Setting positive conservation targets includes the retention of intact prime habitat examples in a condition above a defined minimum standard, or the maintenance of threatened species populations above a prescribed level. Invertebrates have a central role here, with many potential indicator species in terrestrial and freshwater habitats. The identification of criteria for success must include standards against which natural or man-induced changes can be measured. There is

* Dominant – abundant – frequent – occasional – rare.

the need to take a longer view of what constitutes conservation success; after all, a decade of safeguarding a site or population means little if extinction follows subsequently. Many of those working in forestry seem to have developed this longer term view of site management, which is lacking in much conservation planning.

What invertebrate conservation has to offer

Historically, those seeking to promote invertebrate conservation have had to argue for the needs of these animals to be met within the framework of conservation strategies developed to protect higher plants and vertebrates. This has put invertebrate conservation into a defensive posture, which has restricted the development of the subject, and led to the widespread attitude that the subject is too big and complex to tackle. I would like to suggest that because invertebrates are difficult and demanding to conserve, we have something distinctive and different to offer the rest of conservation, namely higher standards to achieve, and deeper ecological insights into what is necessary for long-term conservation success. If we can get this message across, then conservation as a whole, as well as the protection of invertebrates, stands to benefit through our efforts.

Because invertebrates exploit such a wide range of niches, to conserve a fully representative fauna requires the adoption of management policies which are compatible with maintaining the other wildlife groups with which invertebrates are associated. There should not be conflicts between well-formulated proposals to conserve invertebrates, and maintaining the needs of other wildlife groups.

New ways of viewing wildlife conservation. It is a familiar concept that naturalists see, or overlook, different species or other aspects of the natural scene, as a consequence of the kind of wildlife they study. This results from their perceptions being orientated by the need to specialize, in order to find species of interest, or to understand how species interact. When botanists look at an area of semi-natural vegetation, they see different facets of the habitat, compared with ornithologists or entomologists. However, even between entomologists studying different groups there are major differences in the way habitats and their features are viewed. In order to conserve plants and animals better there needs to be better communication between naturalists and conservationists on how habitats should be managed. If entomologists can synthesize their views on what constitutes habitat features of value to a wide range of invertebrates, and help other naturalists and conservationists to 'see' with an entomologist's eye, this is a good first step towards getting invertebrate conservation accepted. It also offers the promise of developing, changing and refining some long-established precepts of nature conservation. This will benefit and renew nature conservation itself in the widest sense.

Novel ecological understanding. A good example is the more dynamic view of how to manage habitats, including the value of early successional stages, which has recently come about. The studies of scarce butterflies by the Institute of Terrestrial Ecology (Dempster & Hall, 1980; Thomas, 1980, 1983*a*,*b*, Thomas *et al.*, 1986; Warren, 1987*a*,*b*,*c*) have contributed greatly to our knowledge of how such factors as vegetation structure, regular management, adult mobility and weather influence their populations. The detailed investigation of a range of threatened, specialized invertebrates with contrasting ecological requirements, offers the chance to improve our understanding of the functioning of other aspects of habitats. For example, the mobility and persistence of insects exploiting ephemeral resources in dead wood, or the effects of contrasting hydrological regimes on wetland invertebrates, could modify current views of the management of forest and wetland habitats respectively.

Invertebrate ecologists are in the forefront of developing the applied science of nature conservation, having new approaches to offer on familiar issues.

Indicator species. Some invertebrates are excellent indicators of past and current ecological conditions. They respond rapidly to environmental change, they include many highly specialized species, they are liable to local extinction if conditions are unsuitable even if only for a single year, and they exploit habitats previously ignored as unimportant by conservationists. They have the potential to tell us much more about the history of our countryside. For example, Rackham (1986) has developed the interpretation of historical and vegetation features for detailed analysis of how man has shaped the British landscape and wildlife. This type of approach has scarcely been tried for most invertebrates. Some studies have analysed observed patterns of distribution, status and habitat fidelity (Dennis, 1977; Harding & Rose, 1986). Others have examined the recent history of our beetle fauna from fossil evidence (Buckland, 1979; Coope, 1970).

Conservation implementation. The consistency of approach needed to conserve most invertebrates successfully will benefit other wildlife in the long term. Although plants may respond to habitat changes more slowly than invertebrates, it is known that eventually they will be adversely affected by, for instance, lack of traditional grassland or heathland management. The high standard of implementing conservation management necessary for invertebrates, is compatible with sound long-term conservation policies for other wildlife. This should give us confidence when promoting well formulated proposals to protect invertebrates, that we are assisting the wider development of nature conservation.

Future trends for invertebrate conservation

As long as economic growth in Britain sustains present levels of road, housing and industrial development, a significant number of important sites will continue to be damaged. Agricultural practices are intensive and damaging to wildlife over much of lowland Britain, giving little chance for many invertebrates to colonize new sites. The picture is similar throughout the EEC, so there is an immense task confronting us if the losses and declines are to be stemmed, and more positive policies are to be adopted to benefit wildlife, including invertebrates, in the wider countryside. Against this must be set a number of encouraging current trends in the growth and development of invertebrate conservation. These give grounds for hope that many sites and species will be conserved as a result of informed efforts to incorporate invertebrates within conservation programmes.

Wider popular appeal. There has been an encouraging growth in the popularity of many invertebrates, both as subjects of television programmes and in books lavishly illustrated by close up colour photographs. The television programmes attract high viewer ratings and the books sell well. Invertebrates appear novel and often bizarre, being obviously different in appearance and behaviour to other animals. This wider interest is laying the foundation for stronger support to the view that invertebrates are worthy of conservation attention and resources. The suggestion that invertebrates should be conserved would have been ridiculed by many only a few years ago, but is now widely accepted.

Recognition of more groups. Butterflies are a key flagship group for invertebrate conservation, their disappearance from many areas has led to concern and support for butterfly conservation from many people who do not have an involvement with other insect groups. The growth of the British Butterfly Conservation Society indicates the potential for conservation of other 'popular' groups. For instance, Odonata (with strong conservation backing from within the British Dragonfly

Society), Orthoptera, bumblebees, hoverflies and ladybirds are all being more widely regarded as interesting, generally beneficial insects, worthy of conservation attention. The next challenge is to bring in such groups as spiders, beetles, bugs, flies and molluscs which are acknowledged by specialists as having good potential indicator species, but as yet are not recognized by many conservationists as meriting much attention. This is likely to change over the coming decades, as invertebrate conservation becomes more broadly established.

The role of computing. More and more entomologists have a computer at home, which can be used to store and process invertebrate records. This takes a lot of the drudgery out of handling records, for example, compiling site lists built up over several years, though it can be hard work catching up with entering a large backlog of data. There are prospects of better data exchange following the development of the biological database package 'Recorder' by my colleague Stuart Ball. This aims to improve communication between organizations holding biological records on computer databases, and should help overcome the current problem of entomologists being requested to send the results from a field visit to NCC, BRC, county trust and the local record centre. Better communication of entomological data is essential if the results of a higher level of recording and study are to benefit conservation.

The role of the BENHS. Members of this Society have a natural interest in seeing their favourite localities managed sympathetically to retain their special interest, and in seeing scarce species conserved for future generations of entomologists to study and enjoy. It is in the Society's and members' own interests to become involved in these matters, and to speak out on conservation issues more in future — as my predecessor Professor Owen has done recently over the management of Windsor Great Park. Plants, birds, reptiles, amphibians and mammals all have their supporters who lobby for conservation of these groups; insects and other invertebrates must not be neglected. Concentrating efforts on an important site, or a threatened species, is a good conservation tactic, and adopting a site or species for intensive study has its own considerable entomological interests and rewards. The Society has an important role to play in encouraging these approaches to entomology.

The prospects for entomology and this Society

There has been a growth in entomological activity generally in Britain in recent years, greatly stimulated by the publication of well-illustrated identification guides, for example, Hammond (1983) for dragonflies, Stubbs & Falk (1983) for hoverflies, and at a more general level the introductory books by Chinery (1973, 1986). There remains the need for more books of this kind to encourage entomologists to take up the study of neglected groups. This Society is playing a vital part here through the publications programme, which aims to product practical guides and keys for use by the field entomologist at a reasonable price. The growth of the national recording schemes, coordinated by the Biological Records Centre, has also done much to increase the amount of invertebrate recording, enabling the activities of many entomologists to contribute towards a better understanding of our fauna. More recently, local record centres have initiated county mapping projects, particularly for the popular butterflies, dragonflies and some moths, but in some cases even extending to other invertebrates such as beetles, flies or some non-insect groups.

These are encouraging signs of increasing interest in British invertebrates among amateur naturalists. However, at the same time there has been a decline in the number of professional entomologists employed in the traditional fields such as taxonomy, invertebrate ecology and agricultural entomology. Posts have been lost, or transferred into other fields, at the national museums, universities and research institutes. However, there has been a modest increase in the number of entomologists employed at local museums and record centres. These trends seem likely to continue for the foreseeable future, with only limited opportunities for careers in entomology, but at the same time thriving recreational entomology, encouraged by the increased leisure time available to many.

The closer links now developing with other European countries will, I am sure, encourage us to have more contacts with our overseas entomological colleagues. We all have a lot to gain by looking at our invertebrate fauna in its European context, and by participating in the preparation of identification works for a wider geographical range, as has already happened with the excellent *Fauna Entomologica Scandinavica* series. In future we can expect that improved communications will further promote international entomological meetings and publications.

There is good potential for increasing membership of the Society to over a thousand and beyond. However, the officers of the Society are already fully committed in maintaining the current activities for a membership of around 700, so a larger membership would probably require some services to be paid for from the increased subscription income. We are a relatively small Society, with a friendly and welcoming attitude towards new members, and this spirit is a tremendous asset for the future. Through its field meetings, indoor meetings and publications, this Society will continue to offer much to the field entomologist in Britain to the end of this century and beyond.

Conclusions

In this address I have attempted to show what entomology and invertebrate conservation have to offer conservation on a wider basis. A major attraction of entomology for many of us is that the subject is never exhausted. Insects and other invertebrates are so rich in species, so elusive in their habits, and ever-changing in their numbers and status. The subject is vast and there is always so much more to find out.

If we are to continue to enjoy the pleasures of entomological discovery in the setting of a pleasant landscape, and if we aspire to hand on the possibility of such enjoyment to our successors, then a forthright advocacy of the needs of insects and other invertebrates is required. We have much to contribute, that is both distinctive and original, to conservation as a whole, and we need to join with other naturalists to make our voice heard on behalf of the special needs of invertebrates. Our hope of success is to lobby persistently, doggedly and fairly for our animals to be conserved. I am reassured to see these attitudes amongst many in this Society; let us work together so that young entomologists in the next century have the opportunity to enjoy the insects and other invertebrates we have been privileged to see.

What we desire to achieve is a countryside where familiar species can be seen more widely and where localities persist which are populated by fully representative assemblages of invertebrates, characteristic of the habitats concerned. This is the substance of our entomological heritage, which must not be replaced by the impoverished shadow of places which may retain their flora but are largely bereft of their invertebrate fauna. Most of what has come down to us has arrived through chance, but it will only survive in future through our own efforts, and with careful planning and design. The contributions of field entomologists, members of this Society, will be vital in giving invertebrates better prospects for the future.

Acknowledgements

It is a pleasure to thank my colleagues in the NCC for all their contributions towards developing invertebrate conservation. Their ideas and expertise have helped me greatly in preparing this address. I am also greatly indebted to those many entomologists in Britain, too numerous to name here, who are pursuing studies relevant to conservation. There is space to cite only a small selection of their work in the references below; their efforts are creating new opportunities to improve our chances of successfully conserving much of our invertebrate fauna in future.

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SHORT COMMUNICATION

A further Gloucestershire locality for *Meloe rugosus* Marsham (Coleoptera: Meloidae). — In a previous note (Alexander, 1989), I suggested that the Cotswold Hills may be a stronghold for the rare oil beetle *Meloe rugosus*. I have since encountered another specimen at a different locality. A female beetle was found by a friend's child in his sandpit in the garden at Ebworth Park Cottages, Fostons Ash, near Sheepscombe (SO 913116), in October 1988. The garden lies at the edge of an expanse of high quality limestone pasture which forms part of the Cotswold Commons & Beechwoods SSSI.

My thanks to John Fleming for bringing the beetle to me. — Keith N. A. Alexander, 22 Cecily Hill, Cirencester, Glos. GL7 2EF.

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